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(54) **OPTIC FOR A LIGHT SOURCE**

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F21V 13/04	(2006.01)
F21V 5/00	(2015.01)
F21Y 101/02	(2006.01)
H05K 3/28	(2006.01)

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CPC ***F21V 5/048*** (2013.01); ***F21V 5/04*** (2013.01); ***F21V 13/04*** (2013.01); ***F21V 23/005*** (2013.01); ***H05K 1/0274*** (2013.01); *F21V 5/007* (2013.01); *F21Y 2101/02* (2013.01); *H05K 3/284* (2013.01); *H05K 2201/10106* (2013.01); *Y10T 29/49124* (2015.01)

(58) **Field of Classification Search**

CPC H05K 2203/1316; H05K 3/284; H05K 1/0274; H05K 2201/10106; F21V 13/04; F21V 23/005; F21V 5/007; F21V 5/04; F21V 5/048; F21Y 2101/02; Y10T 29/49124

USPC 362/308, 311.02, 310

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,935,665	A	6/1990	Murata
5,958,176	A	9/1999	Isshiki et al.
6,040,395	A	3/2000	Isshiki et al.
6,179,436	B1	1/2001	Gitkind
6,188,527	B1	2/2001	Bohn
6,235,862	B1	5/2001	Isshiki et al.
6,518,204	B2	2/2003	Yamakawa et al.
6,997,575	B2	2/2006	Sommers

(Continued)

FOREIGN PATENT DOCUMENTS

EP	2484956	8/2012
JP	2010110894	5/2010

(Continued)

OTHER PUBLICATIONS

Extended European Search Report for European Patent Application No. 14159879.7, mailed Jul. 10, 2014 (6 pages).

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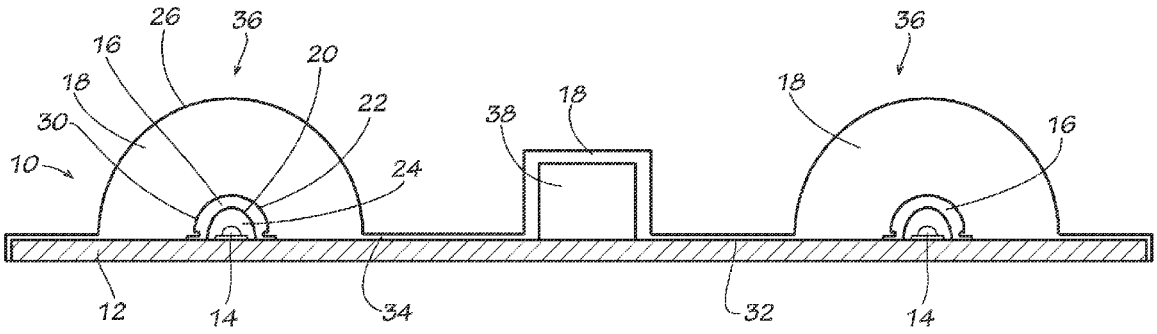
(57) **ABSTRACT**

Disclosed are optics over a light source, such as, but not limited to, an LED on a circuit board. The optic does not entirely encapsulate the LED but rather includes an inner surface such that an air gap exists between the optic and the LED. The optic may include a lens and may conform to the shape of the circuit board.

14 Claims, 6 Drawing Sheets



(56) **References Cited**

U.S. PATENT DOCUMENTS

7,040,779	B2	5/2006	Lamke et al.	
7,259,403	B2	8/2007	Shimizu et al.	
7,273,300	B2	9/2007	Mrakovich	
7,344,902	B2	3/2008	Basin et al.	
7,352,011	B2	4/2008	Smits et al.	
7,355,284	B2	4/2008	Negley	
7,400,439	B2	7/2008	Holman	
7,452,737	B2	11/2008	Basin et al.	
7,496,270	B2	2/2009	Kim et al.	
7,625,986	B2	12/2009	Yoshitake et al.	
7,651,887	B2	1/2010	Morita et al.	
7,651,958	B2	1/2010	Morita et al.	
7,709,853	B2	5/2010	Medendorp, Jr.	
7,748,872	B2 *	7/2010	Holder et al.	362/308
7,763,478	B2	7/2010	Loh et al.	
7,763,697	B2	7/2010	Kato et al.	
7,828,453	B2 *	11/2010	Tran et al.	362/84
7,850,341	B2	12/2010	Mrakovich et al.	
7,857,497	B2	12/2010	Koike et al.	
7,858,408	B2	12/2010	Mueller et al.	
7,858,998	B2	12/2010	Negley	
7,863,392	B2	1/2011	Nakanishi et al.	
7,918,590	B1	4/2011	Li et al.	
7,990,033	B2	8/2011	Nakata et al.	
8,002,435	B2	8/2011	Laporte	
8,070,329	B1 *	12/2011	Bechtel et al.	362/331
8,071,697	B2	12/2011	Frisch et al.	
8,147,742	B2	4/2012	Chen et al.	
8,163,580	B2	4/2012	Daschner et al.	
8,217,412	B2	7/2012	Yuan et al.	
8,258,502	B2	9/2012	Yoshitake et al.	
8,262,970	B2	9/2012	Morita et al.	
8,267,553	B2 *	9/2012	Liang et al.	362/328
8,269,240	B2	9/2012	Negley	
8,287,150	B2	10/2012	Schaefer et al.	
8,293,548	B2	10/2012	Cheng et al.	
8,963,188	B2 *	2/2015	Park	B29C 39/025 174/523
2005/0052737	A1	3/2005	Amemiya et al.	
2005/0259424	A1	11/2005	Zampini et al.	
2006/0097385	A1 *	5/2006	Negley	257/722
2006/0105485	A1 *	5/2006	Basin et al.	438/27
2007/0012940	A1 *	1/2007	Suh	H01L 33/507 257/99
2007/0029569	A1 *	2/2007	Andrews	H01L 33/52 257/99
2007/0121326	A1	5/2007	Nall et al.	
2007/0269747	A1	11/2007	Bahadur et al.	
2008/0033843	A1	2/2008	Warton et al.	
2008/0157114	A1	7/2008	Basin et al.	
2008/0170396	A1	7/2008	Yuan et al.	
2008/0174997	A1	7/2008	Zampini et al.	
2008/0185601	A1	8/2008	Frisch et al.	
2008/0193749	A1	8/2008	Thompson et al.	
2008/0273327	A1	11/2008	Wilcox et al.	
2009/0146175	A1	6/2009	Bahadur et al.	
2009/0225543	A1	9/2009	Jacobson et al.	
2009/0323330	A1	12/2009	Gordin et al.	
2010/0060157	A1 *	3/2010	Shi	H01L 33/507 313/512
2010/0128474	A1	5/2010	Chen et al.	
2010/0195326	A1	8/2010	Boxler et al.	
2011/0007513	A1	1/2011	Zhang et al.	
2011/0057205	A1	3/2011	Mueller et al.	
2011/0068356	A1 *	3/2011	Chiang	H01L 33/507 257/98
2011/0103051	A1	5/2011	Wilcox et al.	
2011/0157891	A1	6/2011	Davis et al.	
2011/0194281	A1	8/2011	Josefowicz et al.	
2011/0216538	A1	9/2011	Logan et al.	
2011/0227235	A1	9/2011	Yoshitake et al.	
2011/0242807	A1	10/2011	Little, Jr. et al.	
2011/0254047	A1	10/2011	Yoshitake et al.	
2011/0272722	A1	11/2011	Chen	
2011/0280014	A1 *	11/2011	Householder et al.	362/235
2011/0320998	A1	12/2011	Perry et al.	
2012/0001208	A1	1/2012	Brick et al.	
2012/0061716	A1	3/2012	Yu et al.	
2012/0065343	A1	3/2012	Bahadur et al.	
2012/0074450	A1	3/2012	Sakurai et al.	
2012/0120654	A1	5/2012	Kobayashi et al.	
2012/0125436	A1	5/2012	Cummings et al.	
2012/0165451	A1	6/2012	Igarashi et al.	
2012/0182739	A1	7/2012	Leung et al.	
2012/0199995	A1	8/2012	Pugh et al.	
2012/0235180	A1	9/2012	Medendorp, Jr.	
2012/0250309	A1	10/2012	Handsaker	
2012/0267650	A1	10/2012	Schubert et al.	
2013/0134609	A1	5/2013	Yoshitake et al.	

FOREIGN PATENT DOCUMENTS

JP	2011138831	7/2011
WO	2004068596	8/2004

* cited by examiner

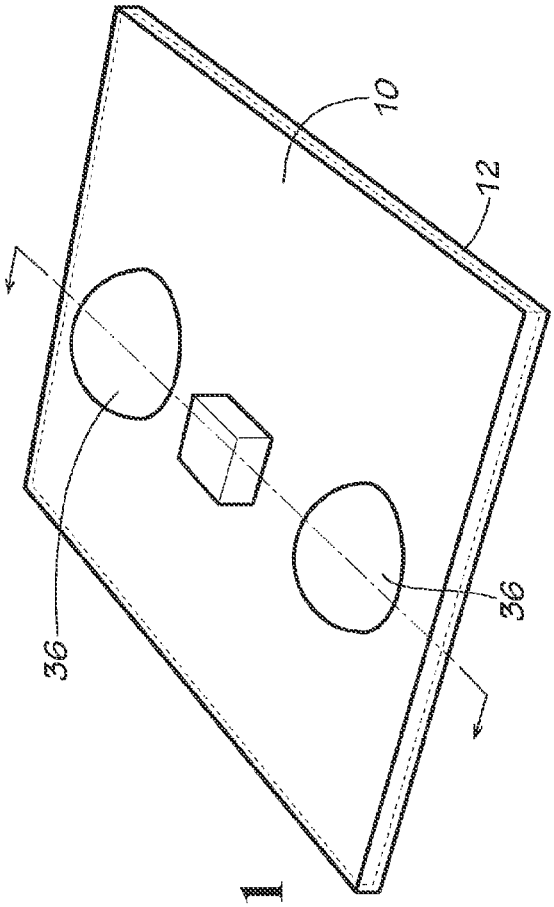


FIG. 1

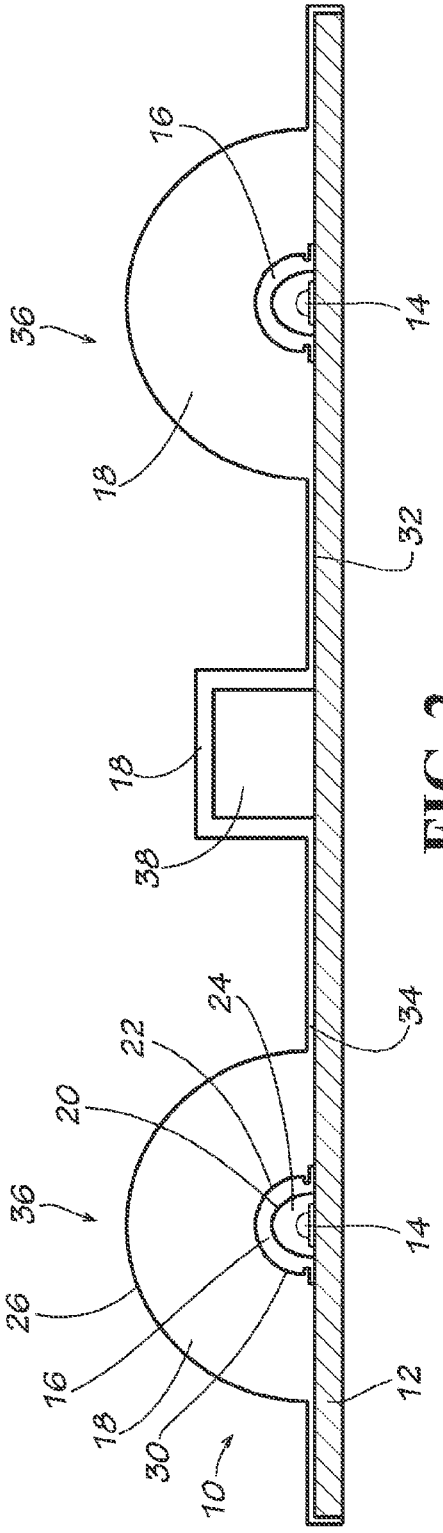


FIG. 2

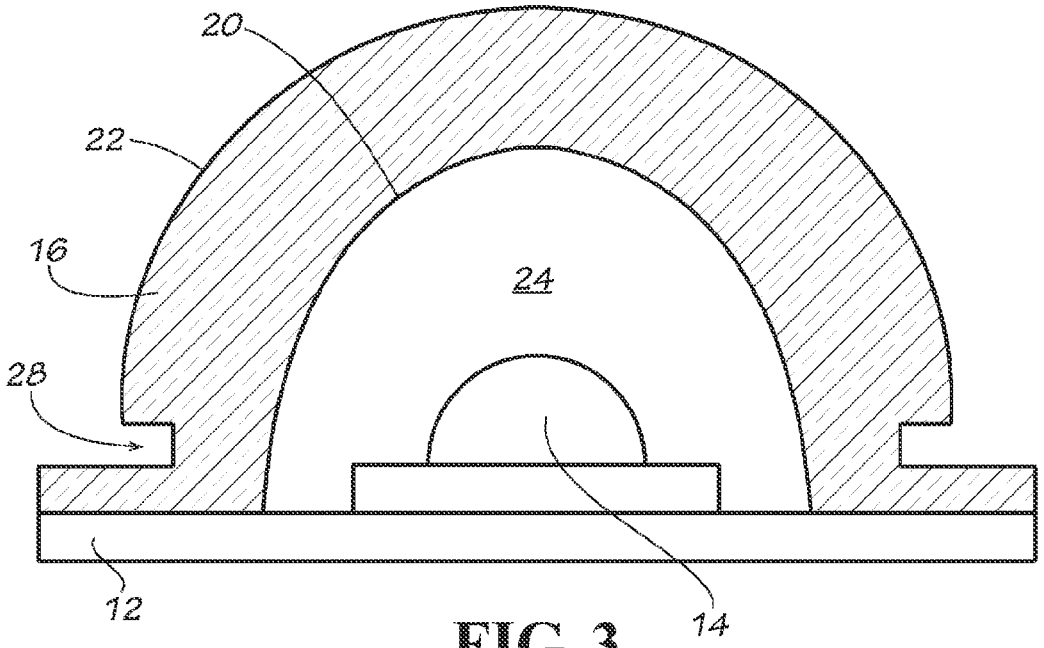


FIG. 3

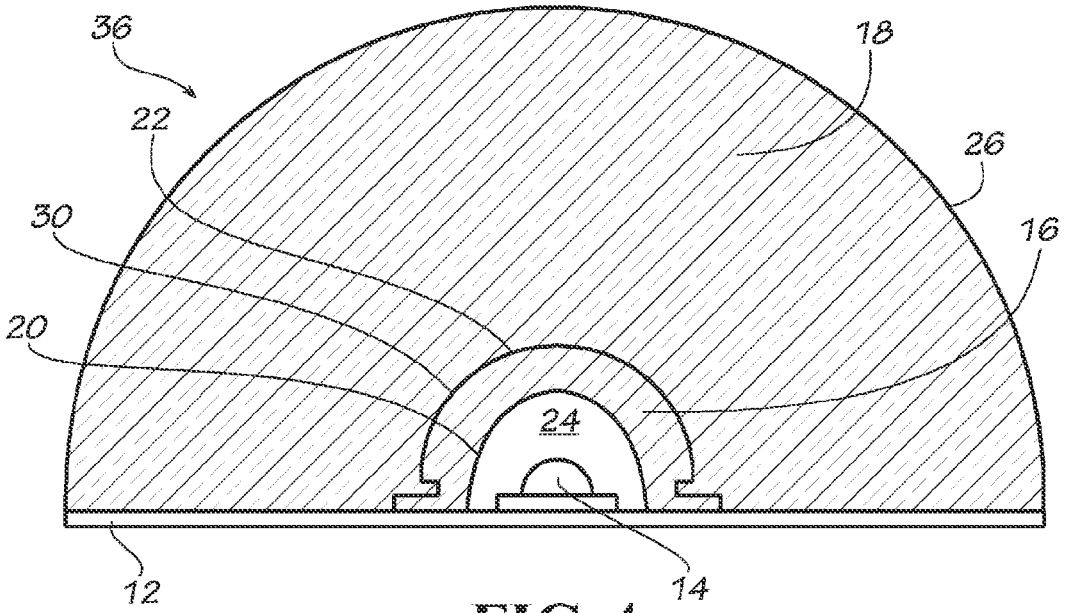


FIG. 4

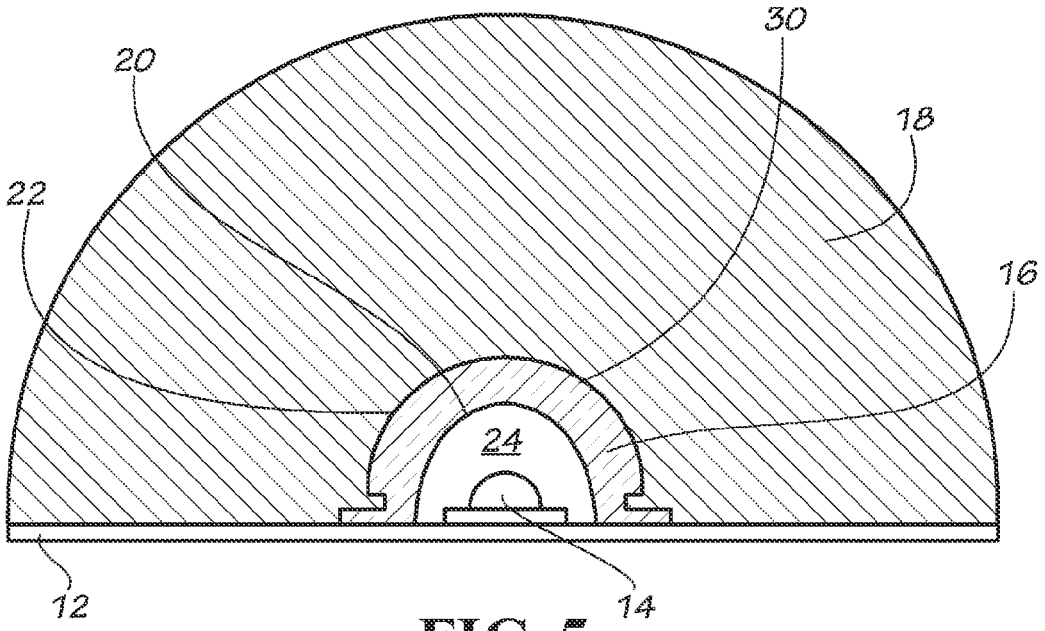


FIG. 5

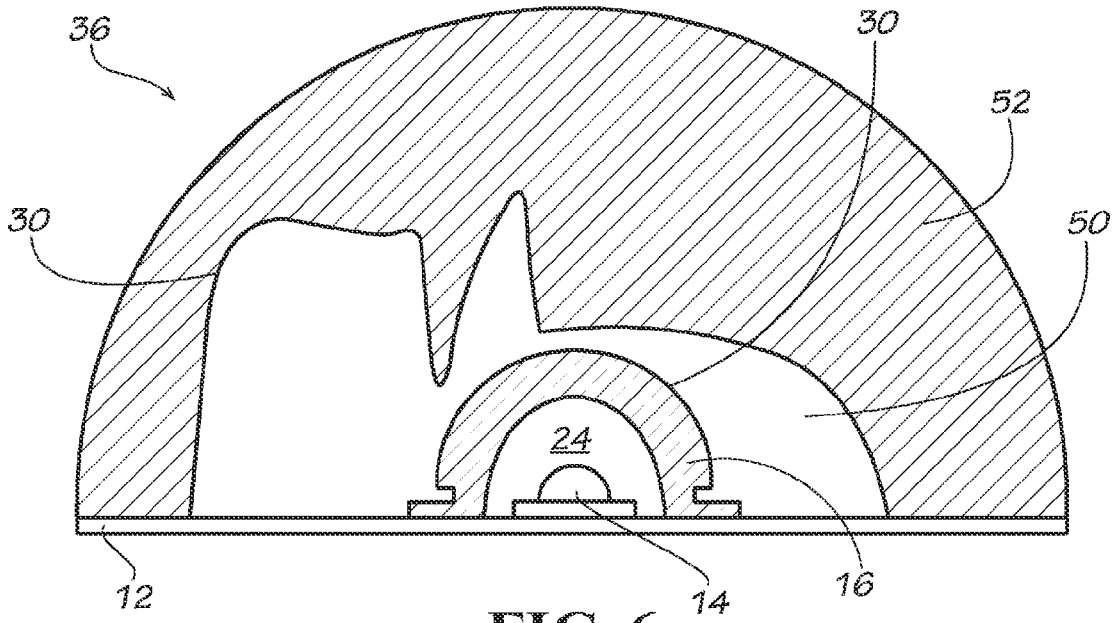


FIG. 6

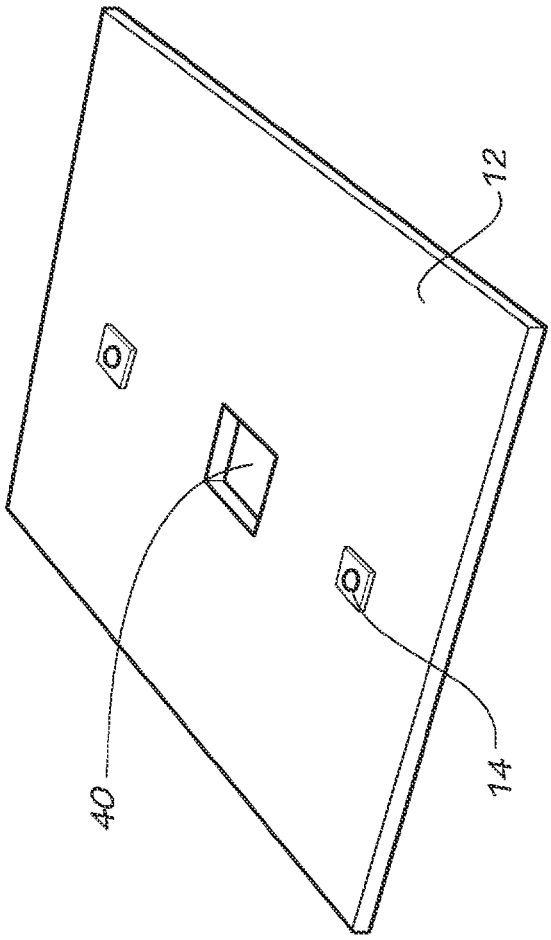


FIG. 7

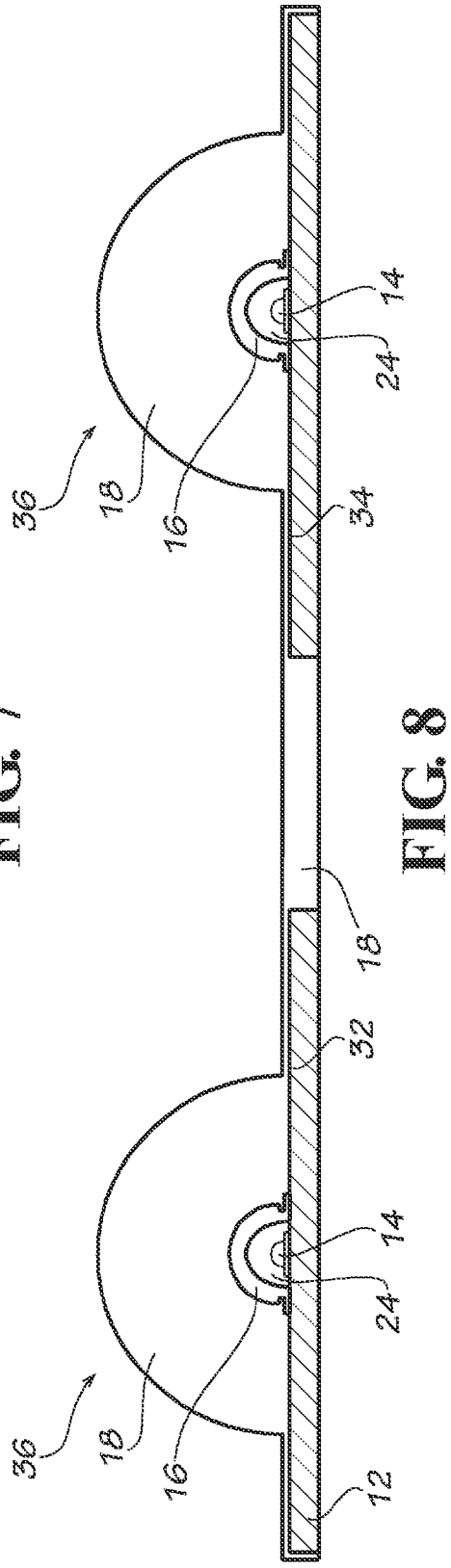


FIG. 8

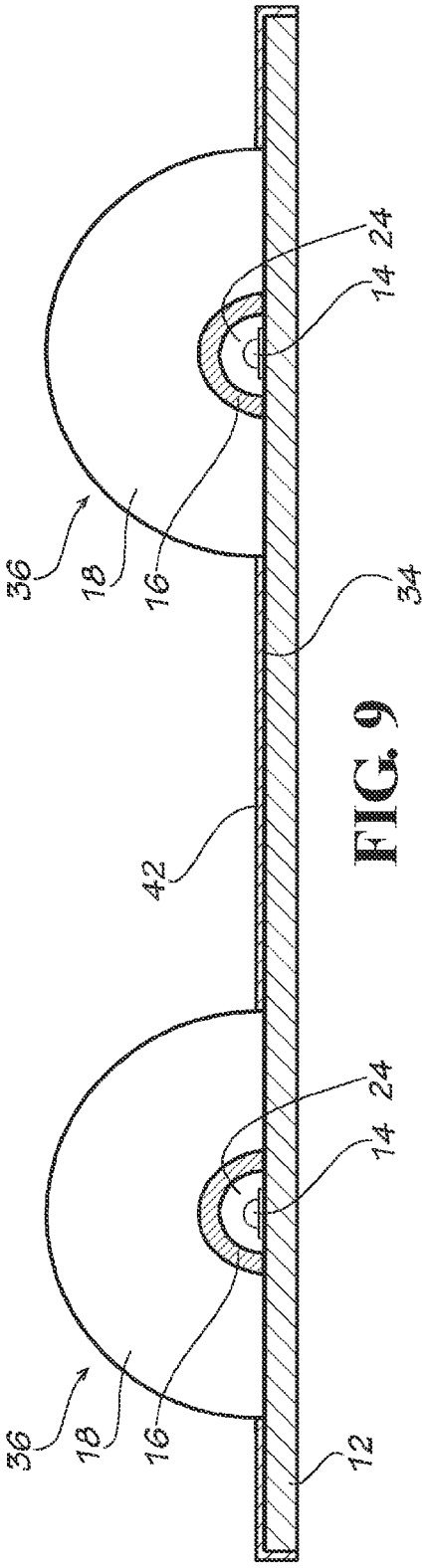


FIG. 9

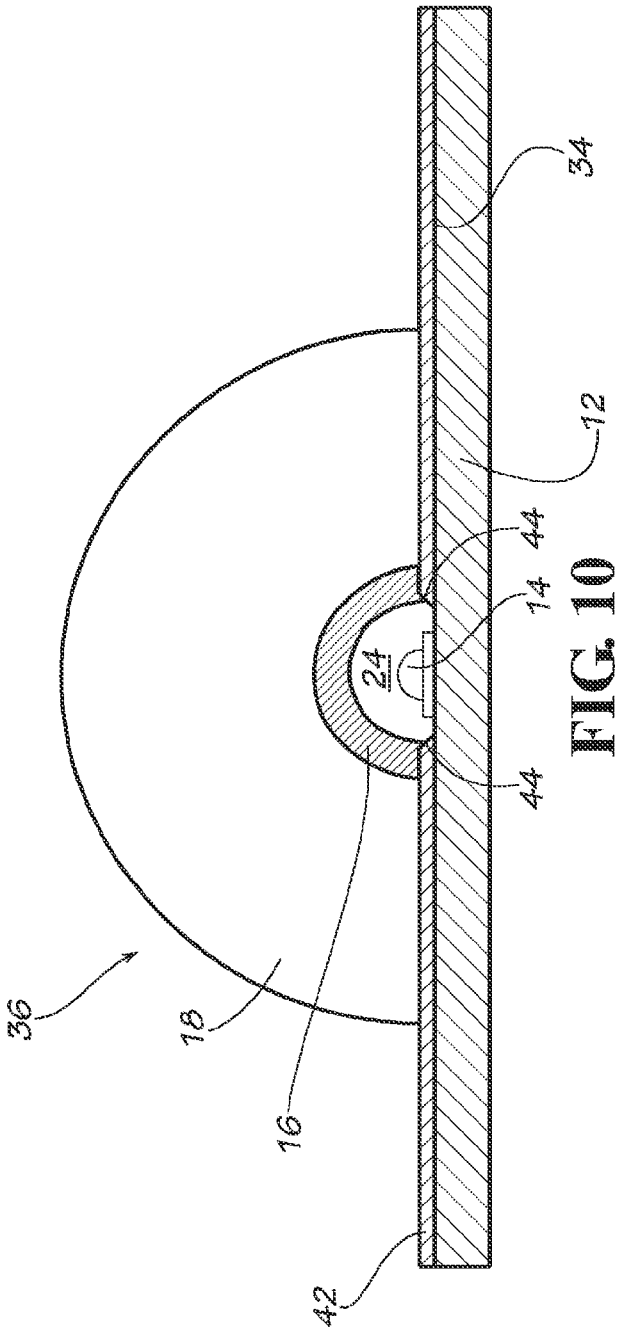


FIG. 10

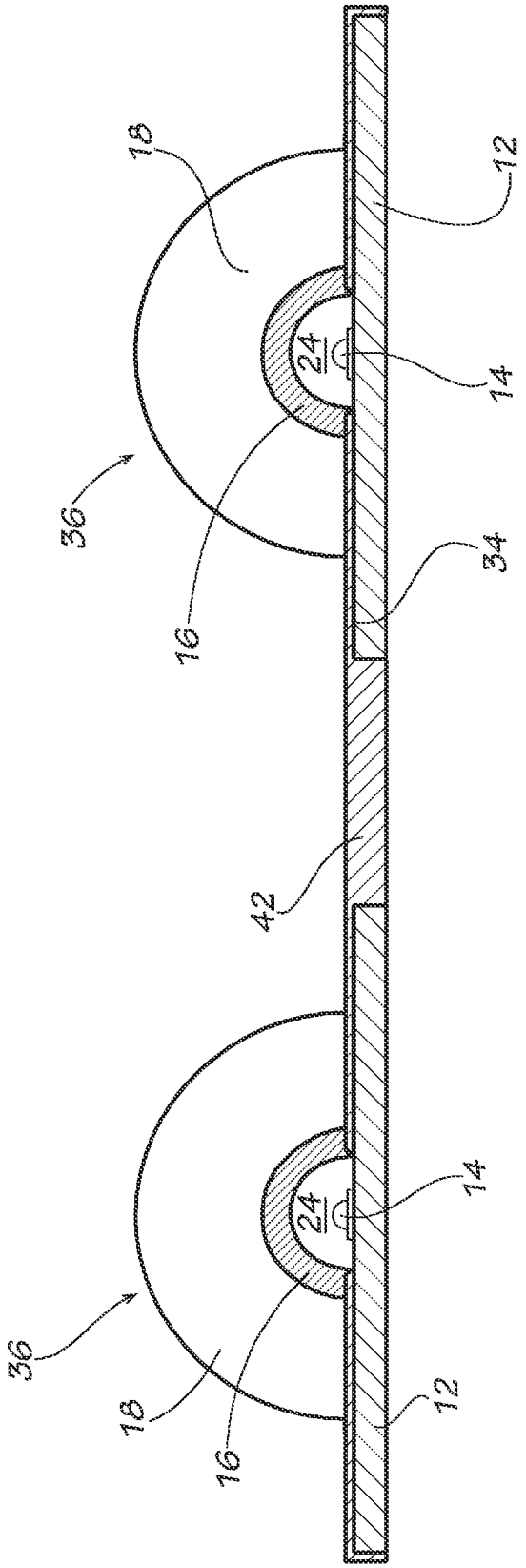


FIG. 11

OPTIC FOR A LIGHT SOURCE

FIELD

Embodiments of the present invention relate to an optic for a light source, such as a light emitting diode.

BACKGROUND

Light emitting diodes ("LEDs") are typically mounted on a printed circuit board ("PCB") and wired to the PCB. Often a silicone or acrylic optic is deposited over the LED to encapsulate the LED such that no space exists between the optic and the LED. Encapsulation of the LED by the optic eliminates a surface that could otherwise be used to control the light distribution.

SUMMARY

Certain embodiments of the present invention provide an optic over a light source, such as, but not limited to, an LED, whereby the optic does not entirely encapsulate the LED but rather includes an inner surface such that an air gap exists between the optic and the LED.

The terms "invention," "the invention," "this invention" and "the present invention" used in this patent are intended to refer broadly to all of the subject matter of this patent and the patent claims below. Statements containing these terms should not be understood to limit the subject matter described herein or to limit the meaning or scope of the patent claims below. Embodiments of the invention covered by this patent are defined by the claims below, not this summary. This summary is a high-level overview of various aspects of the invention and introduces some of the concepts that are further described in the Detailed Description section below. This summary is not intended to identify key or essential features of the claimed subject matter, nor is it intended to be used in isolation to determine the scope of the claimed subject matter. The subject matter should be understood by reference to the entire specification of this patent, all drawings and each claim.

BRIEF DESCRIPTION OF THE FIGURES

Illustrative embodiments of the present invention are described in detail below with reference to the following drawing figures:

FIG. **1** is a top perspective view of an embodiment of an optic positioned on a PCB.

FIG. **2** is a cross-sectional view taken along line **2-2** in FIG. **1**.

FIG. **3** is an isolated cross-sectional view of an embodiment of an inner optic positioned over an LED.

FIG. **4** is an isolated cross-sectional view of an embodiment of an outer optic positioned over the inner optic of FIG. **3**.

FIG. **5** is an isolated cross-sectional view of another embodiment of an outer optic positioned over the inner optic of FIG. **3**.

FIG. **6** is an isolated cross-sectional view of yet another embodiment of an outer optic positioned over the inner optic of FIG. **3**.

FIG. **7** is top perspective view of an embodiment of a PCB.

FIG. **8** is a cross-sectional view of another embodiment of an optic positioned on the PCB of FIG. **7**.

FIG. **9** is a cross-sectional view of yet another embodiment of an optic as well as a reflective surface coating positioned on a PCB.

FIG. **10** is an isolated cross-sectional view of another embodiment of an optic as well as a reflective surface coating positioned on a PCB.

FIG. **11** is a cross-sectional view of yet another embodiment of an optic as well as a reflective surface coating positioned on the PCB of FIG. **7**.

DETAILED DESCRIPTION

The subject matter of embodiments of the present invention is described here with specificity to meet statutory requirements, but this description is not necessarily intended to limit the scope of the claims. The claimed subject matter may be embodied in other ways, may include different elements or steps, and may be used in conjunction with other existing or future technologies. This description should not be interpreted as implying any particular order or arrangement among or between various steps or elements except when the order of individual steps or arrangement of elements is explicitly described.

Embodiments of the present invention provide an optic over a light source, such as, but not limited to, an LED, whereby the optic does not entirely encapsulate the LED but rather includes an inner surface such that an air gap exists between the optic and the LED. FIGS. **1** and **2** illustrate an embodiment of an optic **10** contemplated herein provided on a PCB **12** populated with LEDs **14**. The PCB **12** can be of any shape or size and any number of LEDs **14** may be mounted on the PCB **12** in any orientation.

The optic **10** includes an inner optic **16** and an outer optic **18**. In some embodiments, the inner optic **16** is pre-formed and includes an inner surface **20** and an outer surface **22**. The inner surface **20** and outer surface **22** may be formed in any shape and with any surface enhancements to have the desired optical properties to effectuate the desired bending of the light emitted by the LED **14**. The inner optic **16** is glued or bonded over the LED **14**, such as with silicone or other optical adhesives. See FIG. **3**. This seals the LED **14** within the inner optic **16**. When so positioned, an air gap **24** exists between the LED **14** and the inner surface **20** of the inner optic **16**.

The outer optic **18** is then molded directly over the inner optic **16** so as to have an outer surface **26**. In some embodiments, an interlocking feature (such as key **28**) may be, but does not have to be, provided on the inner optic **16** to enhance retention of the outer optic **18** on the inner optic **16**. Provision of the outer optic **18** over the inner optic **16** serves to protect the outer surface of the inner optic **16** from dirt and debris.

The outer surface **26** of the outer optic **18** may be of any shape and with any surface enhancements to have the desired optical properties to effectuate the desired distribution of the light emitted by the LED **14**.

In some embodiments (see FIG. **4**), the inner optic **16** and outer optic **18** are formed of the identical material (including, but not limited to, silicone) such that the witness line **30** where the outer optic **18** encounters the outer surface **22** of the inner optic **16** is undetectable (although it is shown in FIG. **4** for purposes of illustration).

However, in other embodiments (see FIG. **5**), the materials used to form the inner optic **16** and outer optic **18** are not identical. By way only of example, the inner optic **16** could be formed of a silicone material different from the silicone material forming the outer optic **18**. In such cir-

cumstances, the witness line **30** where the inner optic **16** and outer optic **18** meet is detectable and serves further to bend the emitted light. In such embodiments, the shape and optical properties of the outer surface **22** of the inner optic **16** impacts the light distribution. Moreover, in such embodiments, the inner optic **16** can bend or direct the emitted light at different angles than the outer optic **18**.

It is possible to mold multiple outer optics **18** over the inner optic **16**. For example, FIG. **6** illustrates a first outer optic **50** and a second outer optic **52** provided over inner optic **16**. In some embodiments, the first outer optic **50** is formed of a material that is different from both the inner optic **16** and the second outer optic **52** so that multiple witness lines **30** (having any desired shape) are formed within the optic **10** for directing the emitted light as desired.

In some embodiments, the outer optic **18** is also molded directly onto the upper surface **34** of the PCB **12** such that the lower surface **32** of the optic **10** contacts the upper surface **34** of the PCB **12** but includes lenses **36** (the underside of which is defined by the inner surface **20** of the inner optic **16**) positioned over the LEDs **14**. See FIG. **2**. The upper surface **34** of the PCB **12** between adjacent LEDs **14** is typically populated with electronic components (e.g., traces, resistors, etc.), represented schematically as electronic components **38**, such that the upper surface **34** of the PCB **12** is not planar. The outer optic **18** may be molded directly onto the upper surface **34** of the PCB **12** and over such electronic components **38** so as to seal and protect the electronic components **38** on the PCB **12** way, the lower surface **32** of the optic **10** (more specifically the outer optic **18**) conforms to the shape of such electronic components **38** on the PCB **12**. Because the silicone cure temperature is lower than the solder paste and electronic equipment on the PCB **12**, the disclosed molding process does no damage to such electronic components **38**.

In some embodiments, openings or apertures **40** extend either partially or entirely through the PCB **12** (see FIG. **7**) such that the optic **10** (more specifically the outer optic **18**) partially or entirely fills those openings or apertures **40** to create a strong mechanical interlock between the optic **10** and the PCB **12**. See FIG. **8**. Any number of openings or apertures **40** may be provided on the PCB **12** in any location. Moreover, the outer optic **18** material (such as certain types of silicone) may have thermally transmissive properties such that the outer optic **18** conducts heat generated on the PCB **12** to an underlying substrate (not shown).

In another embodiment, a surface coating **42** of a highly reflective material (which in some embodiments is at least 90-100% reflective and in some embodiments is at least 98-100% reflective) is over-molded onto the upper surface **34** of the PCB **12** so as to conform to the upper surface **34** of the PCB **34**. See FIGS. **9** and **10**. In some embodiments, the highly reflective material is a silicone material. The surface coating **42** may cover any portion of the PCB upper surface **34**. In some embodiments, the surface coating **42** is provided on the PCB **12** adjacent the LEDs **14**, as shown in FIG. **10**. The surface coating **42** may have angled sidewalls **44** adjacent the LEDs **14**. An inner optic **16** may be positioned over the LED **14** (as described above) and then an outer optic **18** molded over the inner optic **16** (as described above) and optionally over a portion or all of the surface coating **42**. The materials of the inner/outer optics **16**, **18** may be the same or different, as described above. The angled sidewalls **44** of the reflective surface coating **42** help capture and reflect/redirect light emitted from an LED **14** approximately 90° off nadir back toward the inner optic **16**, where it can be processed further by the inner optic **16** and outer optic **18**. In embodiments where openings or apertures **40** are provided in the PCB **12**, the reflective surface coating **42** (as opposed to the outer optic **18** as shown in FIG. **8**) may full such openings, as shown in FIG. **11**.

In other embodiments, an outer optic **18** is not molded onto an inner optic **16** and the PCB **12**. Rather, the entire optic **10** is pre-molded and then adhered to the PCB **12**, such as with silicone or other adhesives.

Various types of silicone materials having the properties described herein are available from Dow Corning ("Dow"). For example, Dow's MS-1002 moldable silicone may be useful in certain applications. Moreover, Dow's moldable white reflector material may also be suitable, such as for use as surface coating **42**. However, other sources for moldable silicone materials are known by those skilled in the art.

The foregoing is provided for purposes of illustrating, explaining, and describing embodiments of the present invention. Further modifications and adaptations to these embodiments will be apparent to those skilled in the art and may be made without departing from the scope or spirit of the invention. Different arrangements of the components depicted in the drawings or described above, as well as components and steps not shown or described are possible. Similarly, some features and subcombinations are useful and may be employed without reference to other features and subcombinations. Embodiments of the invention have been described for illustrative and not restrictive purposes, and alternative embodiments will become apparent to readers of this patent. Accordingly, the present invention is not limited to the embodiments described above or depicted in the drawings, and various embodiments and modifications can be made without departing from the scope of the invention.

We claim:

1. A circuit board comprising:

a. an upper surface on which at least one light emitting diode and at least one electronic component are positioned;

b. an optic positioned on the upper surface of the circuit board, wherein the optic comprises:

i. at least one lens positioned over the at least one light emitting diode such that an air gap exists between the at least one lens and at least one light emitting diode; and

ii. a portion integral with the at least one lens and having a lower surface that conforms to the shape of the at least one electronic component so as to seal and protect the at least one electronic component on the circuit board, wherein:

the at least one lens of the optic comprises (i) an inner optic having optical properties and an outer surface and (ii) an outer optic having optical properties different than the optical properties of the inner optic and an inner surface;

the outer surface of the inner optic and the inner surface of the outer optic contact such that no gap exists between the inner optic and the outer optic of the at least one lens;

the inner optic comprises an interlocking feature that the outer optic engages to mechanically interlock the inner and outer optic;

the interlocking feature of the inner optic comprises a groove;

the outer optic comprises a protrusion configured to engage in the groove; and

the protrusion extends in a direction parallel to the upper surface of the circuit board.

2. The circuit board of claim 1, wherein the optic comprises silicone.

3. The circuit board of claim 1, wherein the circuit board further comprises at least one aperture that extends at least partially through the circuit board and wherein the lower surface of the optic extends at least partially within the aperture.

4. The circuit board of claim 3, wherein the at least one aperture extends entirely through the circuit board.

5. The circuit board of claim 1, wherein the inner optic comprises silicone and the outer optic comprises silicone different from the silicone of the inner optic.

6. A circuit board comprising:

a. an upper surface on which at least one light emitting diode and at least one electronic component are mounted;

b. a reflective surface coating having a lower surface that conforms to the upper surface of the circuit board, wherein the reflective surface coating terminates proximate the at least one light emitting diode; and

c. an optic positioned on the upper surface of the circuit board, wherein the optic comprises:

(i) at least one lens positioned over the at least one light emitting diode such that an air gap exists between the at least one lens and the at least one light emitting diode; and

(ii) a portion integral with the at least one lens and having a lower surface that conforms to the shape of the at least one electronic component so as to seal and protect the at least one electronic component on the circuit board, wherein:

the reflective surface coating is adapted to direct light emitted by the at least one light emitting diode toward the at least one lens;

the at least one lens of the optic comprises (i) an inner optic having optical properties and an outer surface and (ii) an outer optic having optical properties different than the optical properties of the inner optic and an inner surface;

the outer surface of the inner optic and the inner surface of the outer optic contact such that no gap exists between the inner optic and the outer optic of the at least one lens;

the inner optic comprises an interlocking feature that the outer optic engages to mechanically interlock the inner and outer optic;

the interlocking feature of the inner optic comprises a groove;

the outer optic comprises a protrusion configured to engage in the groove; and

the protrusion extends in a direction parallel to the upper surface of the circuit board.

7. The circuit board of claim 6, wherein the optic comprises silicone.

8. The circuit board of claim 6, wherein the reflective surface coating comprises silicone.

9. The circuit board of claim 6, wherein the inner optic and the outer optic comprise silicone.

10. The circuit board of claim 6, wherein the optic covers at least a portion of an upper surface of the reflective surface coating.

11. The circuit board of claim 6, wherein the circuit board further comprises at least one aperture that extends at least partially through the circuit board and wherein the reflective surface coating extends at least partially within the aperture.

12. The circuit board of claim 1, wherein the at least one electronic component comprises a trace or resistor.

13. The circuit board of claim 1, wherein:

the at least one light emitting diode comprises a plurality of light emitting diodes; and

the optic covers all of the plurality of light emitting diodes.

14. The circuit board of claim 1, wherein the optic covers the entire upper surface of the circuit board.

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